

# APPROVAL SHEET FOR SUSPENDED LOAD OPERATIONS

SLO-KSC - 2007 - 004

TITLE

Phoenix Spacecraft Lift

DOCUMENT  
NUMBER/TITLE

PREPARED BY

Jack Dekker

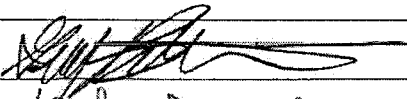
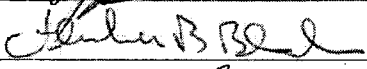



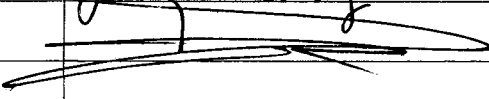
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4/11/07

## REQUIRED APPROVAL

CONTRACTOR \_\_\_\_\_ DESIGN \_\_\_\_\_ R & QA \_\_\_\_\_ OPERATIONS \_\_\_\_\_ SAFETY

NASA \_\_\_\_\_ DESIGN \_\_\_\_\_ R & QA \_\_\_\_\_ OPERATIONS \_\_\_\_\_ SAFETY

TYPE OR PRINT NAME	SIGNATURE	ORG.	DATE
Guy Beutelschies		systems	4/13/07
Fletcher Bloch		Mission Assurance	4-13-07
Tim GASTARDEN		PHY ENG	16 APR 07
Thomas C McCar		OPERATIONS	4/16/07
John C Dollberg		S&MA	4/26/07
JOE TORSAWI		S&BI (COM)	27 APR 07

CONTRACTOR DIRECTOR OF SAFETY

Approval of the suspended load operations analyzed below is requested to support Phoenix processing at PHSF beginning 8 May 2007 through launch.

The Phoenix project is scheduled for processing at KSC PHSF, and the spacecraft lift by crane exposes personnel to suspended load hazard. A photo of the lift configuration taken during earlier MSP01 processing is provided in Figure 1. The lift kit interfaces to the spacecraft at the load limiter brackets, one of three shown in Figure 2. Personnel suspended load exposure occurs during the connection/disconnection of vertical wire rope legs to/from the spacecraft, tensioning turnbuckles and during spacecraft demate/mate from/to a support structure or Delta stage III at the launch vehicle interface. Below is a hazard analysis of this lift per NASA-STD-8719.9 Appendix A.

Requirement A.4.1: The nature of Phoenix is such that spacecraft resource margins (mass, power, volume, schedule) are very tight and are integrally coupled. One of the major factors contributing to these tight margins is the utilization of a spacecraft designed, built and partially tested for the MSP01 mission being re-used for the Phoenix mission opportunity. The as-built nature of Phoenix restricts the possible trade space of design options to address design changes to mitigate the suspended load concern from what might otherwise be possible for a new design.

The spreader plate (Figure 1) used in the Lander Lift Kit is a triangular plate that is capable of lifting the Lander in several configurations, including the Load Limiter lift described herein. The plate is hung on the crane load path via a dedicated 3-leg sling and swivel hoist rings installed in the plate. Three drops connected via swivel hoist rings descend from the plate to attach to the spacecraft via another set of 3 swivel hoist rings (Figure 2). The drops contain turnbuckles with tethered quick-release pins to ease installation. Due to load concerns on the flight hardware, the drops are located on the spreader plate directly above the lift points on the deck to ensure a pure axial load application to the Lander Body (Figure 1). Attaching these drops to the Lander Body and tensioning the lift kit by tightening the turnbuckles require personnel to extend their hands into the zone of danger created by the spreader plate.

The Lander Body is secured to its dollies via an astroring and clamp band installed at the launch vehicle interface in the orientation for spacecraft lift. The launch vehicle interface is a highly critical separation interface. Damage to this interface could force postponement of launch if it affects the mate to the launch vehicle. The LV interface has some tight tolerance surfaces ( $\pm 0.001$  inches) that are extremely susceptible to nicks and dings. For these reasons, the LV interface mate process is a hands-on operation for the Phoenix program. Performing a hands-on mate of the LV interface requires 3 technicians to be below the load while the full weight is still on the hook. This exposure is minimized by staging the technicians outside the zone of danger until the spacecraft is positioned 2 inches above the receiving interface. By employing this "2 inch rule" the receiving dolly is in a position to at least partially assume the load in the event of a failure and give the technicians enough time to exit the hazard zone in the event of a failure. For

de-mating the launch vehicle interface, the process is reversed with the technicians exiting the zone of danger after the Lander has been hoisted from the Astroring by a distance of 2 inches.

Cleaning and inspections of the flight launch vehicle interface are also required between clamp band installations because of the risk of FOD damaging the interface if it is captured between the spacecraft and Astroring, then subjected to the clamping force of the clamp band. The Phoenix flight interface is cleaned between blocking placed on an interface ring. Final inspection of the flight interface ring before flight mate can also be performed between this blocking. The spacecraft is positioned approximately two inches above the blocking providing approximately six inches of working space between blocks.

The preliminary concepts to eliminate the exposure of personnel from the lift fixture as a suspended load failed to produce a baseline approach to this design. A rigid lift fixture that would rest on the spacecraft if the load were lost poses excess risk to the flight article in nominal operations as the fixture is lowered onto the fragile spacecraft; control to lower, even with a hydraset, poses risk that the fixture could improperly impact and damage the spacecraft. A rigid lift fixture also poses problems with CG adjustment before the lift. Turnbuckles are used in the current design to verify even tension on the lift points before spacecraft lift.

Phoenix currently has no means of assembling the single point load train for this lift other than assembling it piece by piece on the hook. For example the master link would be installed first, then a shackle, then a hydraset (optional), then a shackle, then a load cell, then the 3-leg sling master link. Operations personnel are briefed on this concern and will build the load train up on the bench or with blocking methods to avoid non-compliance.

Three technicians have hands-on control at the lift fixture connect points and on the turnbuckles. Three technicians are also present at the launch vehicle interface when the spacecraft is 2 inches or less from the mating surface. These technicians are exposed during the time needed to connect, adjust turnbuckles, guide from the astroring, guide to the receiving mating ring, and disconnect the lift kit from the spacecraft.

Requirement A.4.2: Baseline processing at PHSF includes seven spacecraft lifts:

1. From shipping container to MO dolly
2. To alignment stand
3. To rotation fixture
4. To spin table
5. To dolly
6. To weigh (may include additional connection and disconnection exposures per Delta II requirements)
7. To Delta stage III

Requirement A.4.3: The first lift is scheduled 5/8/07.

Requirement A.4.4: This lift is performed in accordance with Lander Body and System Lift Procedure PHX-SX-001. This procedure was submitted for KSC Safety review as a hazardous operation. The procedure is present and used at PHSF to perform these moves consistent with Lockheed Martin test discipline.

Requirement A.4.5: Five other crane operations in the KSC processing baseline were reviewed and are considered compliant as follows:

1. Shipping container lid lift
2. Heatshield lift
3. Heatshield deployment test lift
4. Rotation fixture assembly and disassembly operations
5. Spin table installation/ removal

Requirement A.4.6: PHSF facility management verified the PHSF cranes have been designed, tested, inspected, maintained, and operated in accordance with NASA STD 8719.9.

Requirement A.4.7: PHSF crane System Assurance Analyses for the East 50-ton bridge crane and West 50-ton bridge crane, SAA01HS11-005 basic and SAA01HS11-003 Rev B respectively, includes a Failure Modes and Effects Analysis, Critical Items List and a hazard analysis. There is no single failure point whose failure would result in dropping the load. Passive components such as rope drum, wire rope, and hook are verified through preventive maintenance. Total lifted mass for the spacecraft lift is approximately 2,000 lbs which is well within the PHSF cranes' capacity.

Requirement A.4.8: Pre-use inspection of the crane is completed within 24 hours before crane use. The need for crane pre-use inspection is coordinated with PHSF facility management, and completion of the inspection is verified before crane operations.

Requirement A.4.9: The crane operator remains at the crane controls at all times when the crane is suspending a load. Crane operators complete the Crane Operation Training Course provided by NASA training. Crane operators will carry two NASA certifications to support the load limiter lift. Either one of two cranes may be used for the load limiter lift: 1) 50-Ton West PHSF highbay crane, ID# CL600200; and 2) 50-Ton East PHSF highbay crane, ID# CL600300. The crane operators will carry their Crane Proficiency Demonstration Record validated by the NASA Examiner.

Requirement A.4.10: Nonessential personnel are kept clear of suspended load operations as noted in the procedure. Clear areas are established by highbay area announcement that non-essential personnel are to keep clear of the crane operation. A warning at the start of the hazardous operation addresses personnel to keep clear of the suspended load except for required tasks as described in Requirement A.4.1 of this SLOAA. The PHSF highbay is a limited access room that minimizes entry by personnel non-essential to the operation, and barriers are used to maintain the

25-foot clear zone specified in the procedure. Lockheed Martin Space Systems Company has instituted a stop command authority by any team member to halt an operation if conditions are observed that are hazardous to personnel or hardware.

Requirement A.4.11: The entire test team participates in a pre-task briefing immediately before the crane lifts as noted in the procedure. Included in the briefing are task assignments.

Requirement A.4.12: Voice communication is used and is adequate for all team members in these operations. Lockheed Martin has instituted a "Stop Command" that empowers every team member to stop operations should imminent danger be recognized to personnel or hardware.

Requirement A.4.13: Phoenix size allows operator and signal person continuous line of site to personnel under the load.

Requirement A.4.14: All crane operations are hazardous operations that are coordinated with NASA Safety which provides opportunity for monitoring. The Phoenix operations may be considered closed as of 9/30/07. That allows for worst case contingencies of failure to launch including safing and preparation for ship.

Requirement A.4.15: The NASA Safety and Mission Assurance Division will provide copies of approved SLOAAs, a list of approved suspended load operations, a list of cranes/hoists used for suspended load operations and copies of the associated FMEA/CIL and hazards analyses to NASA Headquarters.

APPROVAL / DATE:

*for* Melanie J. Mulligan 4/25/07  
Eddie Lebron  
Program/Project S&MA Division Chief

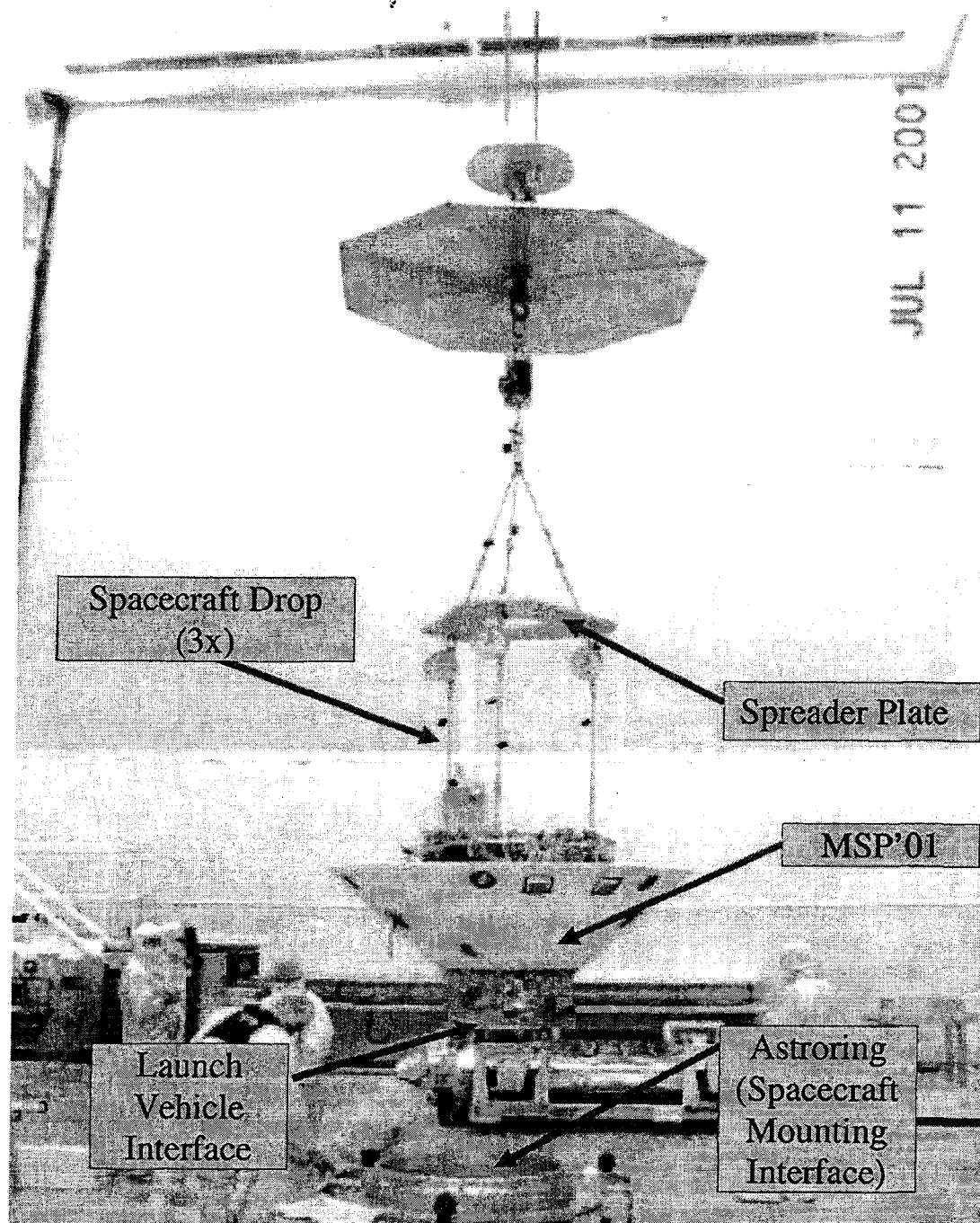


Figure 1: Spacecraft Load Limiter Lift Configuration



Figure 2: Load Limiter Bracket Attach Points